

8.E: Electronic Structure (Exercises)

Exercises (Light)

1. Describe the characteristics of a light wave.
2. What is a characteristic of a particle of light?
3. What is the frequency of light if its wavelength is $7.33 \times 10^{-5} \text{ m}$?
4. What is the frequency of light if its wavelength is 1.226 m ?
5. What is the frequency of light if its wavelength is 733 nm ?
6. What is the frequency of light if its wavelength is 8.528 cm ?
7. What is the wavelength of light if its frequency is $8.19 \times 10^{14} \text{ s}^{-1}$?
8. What is the wavelength of light if its frequency is $3.66 \times 10^6 \text{ s}^{-1}$?
9. What is the wavelength of light if its frequency is $1.009 \times 10^6 \text{ Hz}$?
10. What is the wavelength of light if its frequency is $3.79 \times 10^{-3} \text{ Hz}$?
11. What is the energy of a photon if its frequency is $5.55 \times 10^{13} \text{ s}^{-1}$?
12. What is the energy of a photon if its frequency is $2.06 \times 10^{18} \text{ s}^{-1}$?
13. What is the energy of a photon if its wavelength is $5.88 \times 10^{-4} \text{ m}$?
14. What is the energy of a photon if its wavelength is $1.888 \times 10^2 \text{ m}$?

Answers

1. Light has a wavelength and a frequency.
3. $4.09 \times 10^{12} \text{ s}^{-1}$
5. $4.09 \times 10^{14} \text{ s}^{-1}$
7. $3.66 \times 10^{-7} \text{ m}$
9. 297 m
11. $3.68 \times 10^{-20} \text{ J}$
13. $3.38 \times 10^{-22} \text{ J}$

Exercises (Quantum Numbers for Electrons)

1. Differentiate between a continuous spectrum and a line spectrum.
2. Under what circumstances is a continuous spectrum formed? Under what circumstances is a line spectrum formed?

3. What is the wavelength of light from the hydrogen atom spectrum when $n = 3$?
4. What is the wavelength of light from the hydrogen atom spectrum when $n = 5$?
5. What are the restrictions on the principal quantum number?
6. What are the restrictions on the angular momentum quantum number?
7. What are the restrictions on the magnetic quantum number?
8. What are the restrictions on the spin quantum number?
9. What are the possible values for ℓ when $n = 5$?
10. What are the possible values for ℓ when $n = 1$?
11. What are the possible values for $m\ell$ when $\ell = 3$?
12. What are the possible values for $m\ell$ when $\ell = 6$?
13. Describe the shape of an s orbital.
14. Describe the shape of a p orbital.
15. Which of these sets of quantum numbers is allowed? If it is not, explain why.
 - a. $\{4, 1, -2, +1/2\}$
 - b. $\{2, 0, 0, -1/2\}$
16. Which of these sets of quantum numbers is allowed? If it is not, explain why.
 - a. $\{5, 2, -1, -1/2\}$
 - b. $\{3, -1, -1, -1/2\}$

Answers

1. A continuous spectrum is a range of light frequencies or wavelengths; a line spectrum shows only certain frequencies or wavelengths.
3. 6.56×10^{-7} m, or 656 nm
5. The principal quantum number is restricted to being a positive whole number.
7. The absolute value of $m\ell$ must be less than or equal to ℓ : $|m\ell| \leq \ell$.
9. ℓ can be 0, 1, 2, 3, or 4 .
11. $m\ell$ can be $-3, -2, -1, 0, 1, 2$ or 3 .
13. An s orbital is spherical in shape.
15. a. Because $|m\ell|$ must be less than ℓ , this set of quantum numbers is not allowed.
b. allowed

Exercises (Organization of Electrons in Atoms)

1. Give two possible sets of four quantum numbers for the electron in an H atom.
2. Give the possible sets of four quantum numbers for the electrons in a Li atom.
3. How many subshells are completely filled with electrons for Na? How many subshells are unfilled?
4. How many subshells are completely filled with electrons for Mg? How many subshells are unfilled?
5. What is the maximum number of electrons in the entire $n = 2$ shell?
6. What is the maximum number of electrons in the entire $n = 4$ shell?
7. Write the complete electron configuration for each atom.
 - a. Si, 14 electrons
 - b. Sc, 21 electrons
8. Write the complete electron configuration for each atom.
 - a. Br, 35 electrons
 - b. Be, 4 electrons
9. Write the complete electron configuration for each atom.
 - a. Cd, 48 electrons
 - b. Mg, 12 electrons
10. Write the complete electron configuration for each atom.
 - a. Cs, 55 electrons
 - b. Ar, 18 electrons
11. Write the abbreviated electron configuration for each atom in Exercise 7.
12. Write the abbreviated electron configuration for each atom in Exercise 8.
13. Write the abbreviated electron configuration for each atom in Exercise 9.
14. Write the abbreviated electron configuration for each atom in Exercise 10.

Answers

1. $\{1, 0, 0, 1/2\}$ and $\{1, 0, 0, -1/2\}$
3. Three subshells ($1s, 2s, 2p$) are completely filled, and one shell ($3s$) is partially filled.
5. 8 electrons
7. a. $1s^2 2s^2 2p^6 3s^2 3p^2$
b. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^1$
9. a. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10}$
b. $1s^2 2s^2 2p^6 3s^2$

11. a. $[\text{Ne}]3s^23p^2$

b. $[\text{Ar}]4s^23d^1$

13. a. $[\text{Kr}]5s^24d^{10}$

b. $[\text{Ne}]3s^2$

Exercises (Periodic Table)

1. Where on the periodic table are *s* subshells being occupied by electrons?
2. Where on the periodic table are *d* subshells being occupied by electrons?
3. In what block is Ra found?
4. In what block is Br found?
5. What are the valence shell electron configurations of the elements in the second column of the periodic table?
6. What are the valence shell electron configurations of the elements in the next-to-last column of the periodic table?
7. What are the valence shell electron configurations of the elements in the first column of the *p* block?
8. What are the valence shell electron configurations of the elements in the last column of the *p* block?
9. From the element's position on the periodic table, predict the electron configuration of each atom.
 - a. Sr
 - b. S
10. From the element's position on the periodic table, predict the electron configuration of each atom.
 - a. Fe
 - b. Ba
11. From the element's position on the periodic table, predict the electron configuration of each atom.
 - a. C
 - b. Ar
12. From the element's position on the periodic table, predict the electron configuration of each atom.
 - a. Cl
 - b. K
13. From the element's position on the periodic table, predict the electron configuration of each atom.
 - a. Ge
 - b. C
14. From the element's position on the periodic table, predict the electron configuration of each atom.
 - a. Mg
 - b. Cl

Answers

1. the first two columns
3. the *s* block

5. ns^2

7. ns^2np^1

9. a. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2$
b. $1s^2 2s^2 2p^6 3s^2 3p^4$

11. a. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$
b. $1s^2 2s^2 2p^6 3s^2 3p^6$

13. a. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^2$
b. $1s^2 2s^2 2p^2$

Exercises (Periodic Trends)

1. Write a chemical equation with an IE energy change.
2. Write a chemical equation with an EA energy change.
3. State the trends in atomic radii as you go across and down the periodic table.
4. State the trends in IE as you go across and down the periodic table.
5. Which atom of each pair is larger?
 - a. Na or Cs
 - b. N or Bi
6. Which atom of each pair is larger?
 - a. C or Ge
 - b. Be or Ba
7. Which atom of each pair is larger?
 - a. K or Cl
 - b. Ba or Bi
8. Which atom of each pair is larger?
 - a. Si or S
 - b. H or He
9. Which atom has the higher IE?
 - a. Na or S
 - b. Ge or Br
10. Which atom has the higher IE?
 - a. C or Ne
 - b. Rb or I
11. Which atom has the higher IE?
 - a. Li or Cs
 - b. Se or O
12. Which atom has the higher IE?

- a. Al or Ga
- b. F or I

13. A third-row element has the following successive IEs: 738; 1, 450; 7, 734 and 10, 550 kJ/mol Identify the element.
14. A third-row element has the following successive IEs: 1,012; 1, 903; 2, 912; 4, 940; 6,270 ; and 21, 300 kJ/mol Identify the element.
15. For which successive IE is there a large jump in IE for Ca ?
16. For which successive IE is there a large jump in IE for Al?
17. Which atom has the greater magnitude of EA?
a. Cor F
b. Al or Cl
18. Which atom has the greater magnitude of EA?
a. K or Br
b. Mg or S

Answers

1. $\text{Na(g)} \rightarrow \text{Na}^+(\text{g}) + \text{e}^- \Delta H = \text{IE}$ (answers will vary)
3. As you go across, atomic radii decrease; as you go down, atomic radii increase.
5. a. Cs
b. Bi
7. a. K
b. Ba
9. a. S
b. Br
11. a. Li
b. O
13. Mg
15. The third IE shows a large jump in Ca.
17. a. F
b. Cl

Additional Exercises

1. What is the frequency of light if its wavelength is 1.00 m ?
2. What is the wavelength of light if its frequency is 1.00 s^{-1} ?
3. What is the energy of a photon if its wavelength is 1.00 meter?
4. What is the energy of a photon if its frequency is 1.00 s^{-1} ?

5. If visible light is defined by the wavelength limits of 400 nm and 700 nm, what is the energy range for visible light photons?
6. Domestic microwave ovens use microwaves that have a wavelength of 122 mm. What is the energy of one photon of this microwave?
7. Use the equation for the wavelengths of the lines of light in the H atom spectrum to calculate the wavelength of light emitted when n is 7 and 8.
8. Use the equation for the wavelengths of the lines of light in the H atom spectrum to calculate the wavelengths of light emitted when n is 5 and 6.
9. Make a table of all the possible values of the four quantum numbers when the principal quantum number $n = 5$.
10. Make a table of all the possible values of m_ℓ and m_s when $\ell = 4$. What is the lowest value of the principal quantum number for this to occur?
11.
 - a. Predict the electron configurations of Sc through Zn.
 - b. From a source of actual electron configurations, determine how many exceptions there are from your predictions in part a.
12.
 - a. Predict the electron configurations of Ga through Kr.
 - b. From a source of actual electron configurations, determine how many exceptions there are from your predictions in part a.
13. Recently, Russian chemists reported experimental evidence of element 117. Use the periodic table to predict its valence shell electron configuration.
14. Bi (atomic number 83) is used in some stomach discomfort relievers. Using its place on the periodic table, predict its valence shell electron configuration.
15. Which atom has a higher ionization energy (IE), O or P?
16. Which atom has a higher IE, F or As?
17. Which atom has a smaller radius, As or Cl?
18. Which atom has a smaller radius, K or F?
19. How many IEs does an H atom have? Write the chemical reactions for the successive ionizations.
20. How many IEs does a Be atom have? Write the chemical reactions for the successive ionizations.
21. Based on what you know of electrical charges, do you expect Na^+ to be larger or smaller than Na?
22. Based on what you know of electrical charges, do you expect Cl^- to be larger or smaller than Cl?

Answers

1. $3.00 \times 10^8 \text{ s}^{-1}$
3. $1.99 \times 10^{-22} \text{ J}$
5. $4.97 \times 10^{-19} \text{ J}$ to $2.84 \times 10^{-19} \text{ J}$
7. $3.97 \times 10^{-7} \text{ m}$ and $3.89 \times 10^{-7} \text{ m}$, respectively

9.

n	ℓ	$m\ell$	m_s
5	0	0	1/2 or -1/2
5	1	-1, 0, 1	1/2 or -1/2
5	2	-2, -1, 0, 1, 2	1/2 or -1/2
5	3	-3, -2, -1, 0, 1, 2, 3	1/2 or -1/2
5	4	-4, -3, -2, -1, 0, 1, 2, 3, 4	1/2 or -1/2

11. a. The electron configurations are predicted to end in $3d^1$, $3d^2$, $3d^3$, $3d^4$, $3d^5$, $3d^6$, $3d^7$, $3d^8$, $3d^9$, and $3d^{10}$.

b. Cr and Cu are exceptions.

13. Element 117's valence shell electron configuration should be $7s^27p^5$.

15. O

17. Cl

19. H has only one IE: $H \rightarrow H^+ + e^-$

21. smaller

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